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Voluntary Spawning, Early Development, and Completion of the Life Cycle of Spotted Sand Bass *Paralabrax maculatofasciatus* in the Laboratory

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Abstract.—Spawning behavior and development of spotted sand bass *Paralabrax maculatofasciatus* were studied in the laboratory. Captive fish (15–20 cm standard length) spawned in 100-L aquaria at 24 C and 35 ppt salinity with a controlled photoperiod (13 h light: 11 h dark). Distinct courtship coloration and displays were observed. Courtship began near noon and continued all afternoon. Spawning occurred toward the surface during late afternoon. Development from fertilization to 3 d after hatching is described. Hatching occurred in 24–25 h at 24 C. Larvae were reared in 100-L aquaria with microalgae, rotifers, and *Artemia*. First feeding occurred 3 d after hatching, and 5.3% survival was obtained at 17 d (4.1-mm mean notochord length, 1.7–5.5 mm range). On a diet of minced clams and fish, first maturity was reached at 7.5 mo (19.5 g mean weight, 8.3–37.9 g range and 90 mm mean standard length, 66–116 mm range).

Some members of the family Serranidae have good potential for aquaculture because of their value, adaptability to captivity, ease of spawning, good growth, and good feed conversion (Tucker 1994). At least 31 species of serranids have been induced to spawn with hormones, and 27 have spawned voluntarily in captivity (Tucker 1994, 1998). The spotted sand bass *Paralabrax maculatofasciatus* is an important food fish in western Mexico. Surveys made during the last decade have shown some advantages of this species for culture. Matus-Nivon et al. (1990), using collected wild eggs, compared the growth, survival, larval behavior (cannibalism, school formation), handling tolerance, and effort required for rearing of 16 marine fish species. Spotted sand bass was rated among the top three. Additionally, spotted sand bass exhibited high adaptability to captivity and acceptable growth in captivity. When fed trash fish in cages, they can grow from 19.8 g (10 cm total length) to 400–500 g in 6–7 mo (Avilés-Quevedo et al. 1995). Maximum size is 800–1,800 g (35–40 cm total length).

There are three previous reports of this species being conditioned or induced to spawn. Rosales-Velázquez et al. (1992) obtained voluntary spawning by control of temperature and photoperiod. Ovulation has been induced by injection of gonadotropin releasing hormone-analog (GnRHa) (Oda et al. 1993) and human chorionic gonadotropin (HCG) (Pérez-Mellado in Tucker 1994).

This report describes spawning behavior

of captive wild adults, development of eggs and early larvae, and spawning of laboratory reared spotted sand bass.

Materials and Methods

Voluntary Spawning of Captive Wild Adults

During spring 1993, adult spotted sand bass were captured at La Paz inlet by hook and line or trawl. The fish were held in indoor 600-L fiberglass tanks (light blue, 90-cm diameter, 120-cm depth), with temperature at 24 C, salinity of 35 ppt, and photoperiod of 13 h light : 11 h dark. They were fed minced fish once a day to satiation. A semi-closed system was employed. Unconsumed food and feces were removed, and 50% of the water was exchanged every day. After 3 wk, sex and maturity were determined by external examination, and biopsies were taken from the ovaries with surgical polyethylene tubing. Two females and one male were placed in each of five 100-L (90×35×40 cm) transparent plexiglass aquaria. Similar conditions (24 C, 35 ppt, 13 light : 11 dark, 40-W Vitalite® 60 cm from the surface) and feeding were maintained.

After 15 d, spawning was detected and a video camera was used to record behavior in each aquarium for the next 20 d. Every day during the water change, all eggs from each aquarium were gently collected in a 500-μm sieve. The eggs were separated in a water column by differences in buoyancy, and the volume of viable eggs was measured using the procedure described by Bromage (1995). About 200 viable eggs from each spawn were placed in a 1-L flask with filtered sterilized seawater. All flasks were maintained without aeration in a water bath at 24 C. Hatched eggs were counted 24 h after hatching. Percent hatching was based on the total eggs spawned.

Early Development

Development at 24 C was described from eggs produced by 20 females and 20 males in a recirculating system (Rosales-Velázquez 1997). The system consisted of four 1,100-L cylindrical fiberglass tanks, equipped with a pump, protein skimmer, ultraviolet light sterilizer, and two types of biological filters, including bio-balls and fluidized beds. A video camera was also placed to record the behavior during the courtship. The system was initially filled with seawater, 0.4-μm filtered and UV-disinfected. Buoyant eggs were collected via the central standpipe to a 500-μm sieve for each tank. Several females and males contributed to each spawn. Recently spawned eggs were placed in flasks of seawater in a water bath at 24 C. Samples of eggs and larvae were taken hourly during a 48-h period and were observed at 100× (Olympus® SZ40 microscope with photographic and video digitalization system); measurements were made directly with Image-Pro® 4.0 software (Media Cybernetics, Silver Springs, Maryland, USA).

Larvae were reared from 10,000 eggs stocked in a 100-L (90×35×40 cm) transparent plexiglass aquarium. Foods were: *Nannochloris* sp. (Hernández-Ceballos 1996) at 200,000 cells/mL; *Brachionus plicatilis,* 5/mL during 2–7 d after hatching (dah), 10 mL during 8–17 dah; and *Artemia* (SaltCreek®) nauplii at 1/mL during 15–17 dah. Rotifers were fed *Nannochloris* sp., and *Artemia* were not fed.

Growth and Spawning of Reared Fish

Juvenile spotted sand bass (N = 280, 40-d-old) produced as described above were maintained until they spawned in indoor 600-L (light blue, 90-cm diameter, 120-cm depth) fiberglass tanks with filtered seawater at 24 C, 35 ppt salinity, and natural light (between 400 and 1,200 Lx, 12–13 h light/d). They were fed to apparent satiation with live wild *Artemia* (from San Juan Nepomuseno Saline) during 40–60 dah, then the *Artemia* gradually were shifted to clam meal and fish meal; only fish meal was used after 75 dah. A semi-closed system was employed; unconsumed food and feces were gently removed and 30% of the water was

TABLE 1. *Days on which spotted sand bass spawned in five aquariums (two females and one male in each).*

Aquarium	Day 1	2	3	4	5	6	7	8	9	10	11	12	13	...	20
A			x						x		x				
B							x								
C			x		x		x		x		x		x		
D															
E							x						x		

x Documented spawn.

exchanged every day. A 500-μm sieve was placed in the drainage of each tank to check for eggs. When spawning began, the length weight and sex of each fish were determined as previously described.

Results

Voluntary Spawning of Captive Wild Adults

Of 147 captured wild fish, 55% were mature females (152 ± 45 mm standard length, SL, mean ± SD), 33% mature males (210 ± 46mm), and 12% immature (119 ± 65 mm). Twelve spawns in the aquarium were recorded (Table 1). Based on individual behavior, the shortest interval between spawns by a female was 2 d. Egg production was 500–8,700 per aquarium per day, with no obvious relationship (P = 0.203) between female size and egg number (R^2 = 0.269, F = 1.84, N = 8) or spawning frequency. Mean fertilization rate was 95% (range 92.5–96.4%), and mean hatching rate was 88% (range 76–93%).

During the first few hours of the day, the fish rested on the bottom or swam slowly. Near noon on spawning days, activity of the male increased, with surface swimming and poking of the head through the surface (Fig. 1A); the anterior maxillary area and pelvic fins of the male were darkened. During the afternoon, swimming activity increased. The male would approach the flank of a female, which would respond by displaying and vibrating her fins, rising off the bottom, curving her body toward the male, swimming at the surface, settling to the bottom, and resting on extended pelvic fins, then repeating the sequence several times (Fig. 1B). After a series of approaches and displays, the female's fins darkened, five or six vertical dark bars formed on her side, and she swam near the surface with the male (Fig. 1C). During late afternoon, both swam with their heads up (Fig. 1D), and spawning occurred at the surface, usually once a day beginning between 1 h and 30 min before sunset. Spawning behavior continued for several minutes after the lights were turned off.

During the first spawning event in some aquariums, one female dominated the other, attacking the side of the subordinate when the subordinate female approached either of the other two fish. Spawning of subordinate females was not observed until the second spawning day, during which both females participated. In two cases of 12 recorded, a female began the courtship by swimming near the surface and approaching the male, which rested on the bottom.

During preliminary observations of spawning by five wild females and five wild males in each of four recirculating 1,100-L tanks, one male dominated the others, which did not spawn. Subordinate males were pale and remained still on the bottom, if they moved, the dominant male forced them back to the bottom.

Early Development

Unfertilized eggs had a mean diameter of 862 μm (range 841–883 μm, N = 45); the single oil globule had a mean diameter of 164 μm (range 160–170 μm). Within 2–4 h after fertilization (haf), the blastodisc was

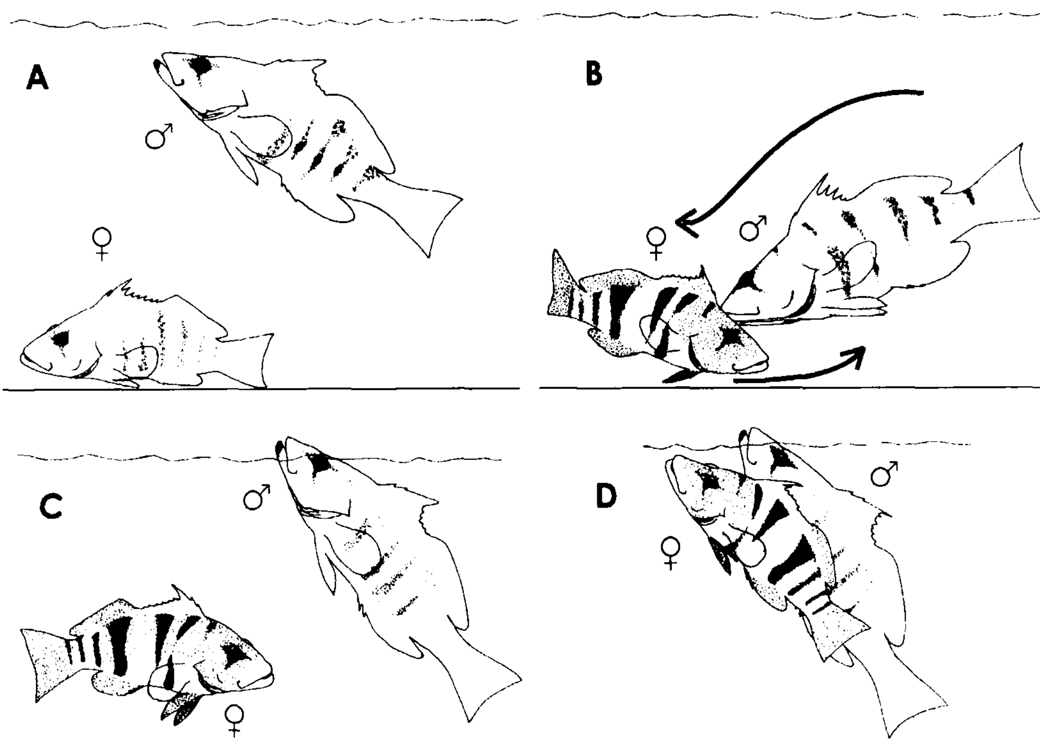

FIGURE 1. *Characteristic stages during spawning by spotted sand bass. A. Male at midday. B. Male (Right) approaching the flank of a female (Left) C. Female (Left) and male (Right) active at late afternoon D. Female (Left) and male (Right) during the eggs releasing.*

formed (Fig. 2A). At 6 haf, the germinal ring was formed and epiboly began (Fig. 2B). The embryo formed at 10–11 haf (Fig 2C). Optic vesicles and trunk somites appeared at about 12 haf, and the blastopore closed at the posterior tip of the embryonic axis (Fig 2D). At 15–16 haf, somites were present along most of the embryo, the tip of the tail had thickened slightly, the tail bulb had become rounded and had started to separate from the yolk mass, and primordial eye lenses were forming (Fig. 2E). Prior to hatching, trunk melanophores were present, the tail was separate from the yolk, the heart was beating, and the embryo moved (Fig. 2F). Hatching occurred at about 24–25 haf.

After hatching, eye lens development continued, the choroidal fissure appeared, and trunk myomeres increased. By the time of eye pigmentation (2–3 dah), the straight gut exhibited peristaltic contractions, chondrification of jaws had begun, and the yolk was mostly exhausted. First feeding occurred at about 3 dah.

Growth in length was slow or slightly negative just after feeding (Fig. 3). Survival from the tail-bud stage to 17 dah (flexion) was 5.3%, and mean NL was 4.1 mm (1.7–5.5 mm).

Growth and Spawning of Reared Fish

A 74% mortality was recorded from 40 dah to 7.5 mo; however, considering the mortality recorded during the larval rearing period, the total survival was 0.37%. The growth during this time was lower than found by Avilés-Quevedo et al. (1995). When reared spotted sand bass were about 7.5 mo old (mean weight 19.5 g (range 8.3–37.9 g); females 90 mm mean SL (range 66–116 mm), males 91 mm mean SL (range 90–100 mm), they began to spawn. Eighty percent were female, 17% male, and 3%

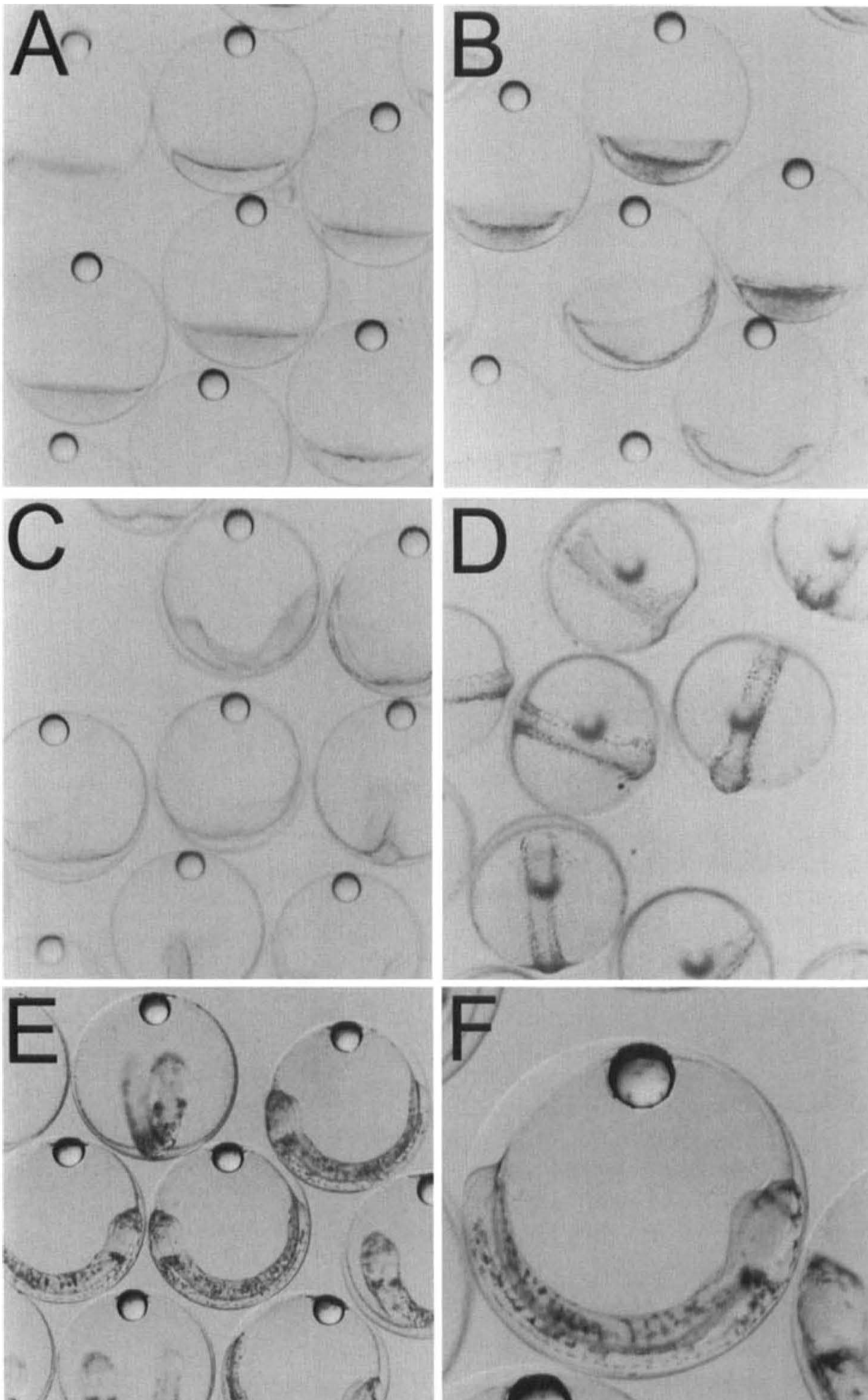

FIGURE 2. *Photomicrographs of selected developmental stages of spotted sand bass raised at 24 C. A. 3.5 h after fertilization (haf). B. 6 haf. C. 10 haf. D. 13 haf. E. 16.5 haf. F. 22 haf.*

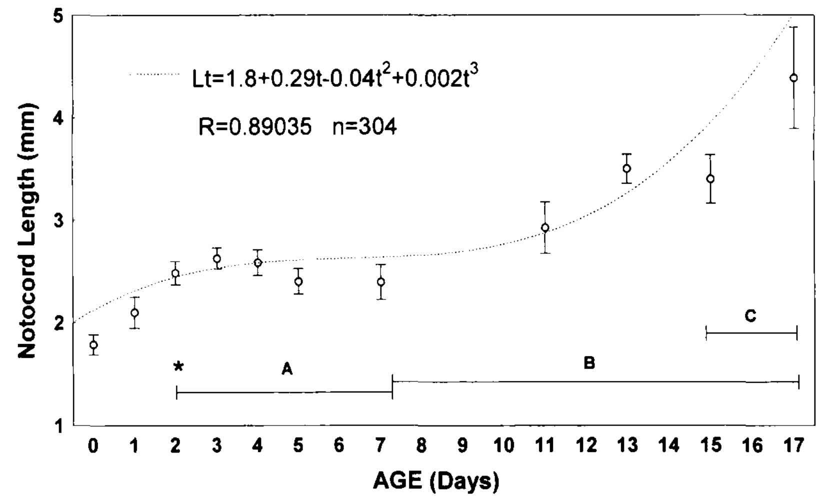

FIGURE 3. *Growth of spotted sand bass (mean body length; notochord length before flexion was complete, then standard length). First feeding indicate by an asterisk. A. Fed 5 rotifers/mL. B. Fed 10 rotifers/mL. C. Fed* Artemia *nauplius/mL.*

undetermined (Fig. 4). Combined fertilization and hatching rates typically were near 95% ($N = 4$). Spawning continued at least once by week until the trial was ended at 14 mo.

Discussion

Voluntary Spawning of Captive Wild Adults

Like many other serranids (Tucker 1998), this very adaptable species spawns easily in captivity. Previously, voluntary spawning was obtained in recirculating indoor tanks (Rosales-Velázquez et al. 1992) and in concrete tanks with open flow (Avilés-Quevedo et al. 1995). Both reported unpredictable fluctuations in spawning frequency and number of eggs produced. We believe those fluctuations can be improved by refinements in broodstock management. In wild populations, females outnumber males (Lluch 1995; Avilés-Quevedo et al. 1995). We found that one male dominated in the 1,100-L tank and one male spawned with two females in the 100-L aquariums. It is likely that more than two females with one male per tank would constitute a more efficient broodstock. Further, we observed a 2-d minimum interval between spawns, and Oda et al. (1993) estimated a minimum interval of 1.5 d between spawns. During our experiments we found more reproductive activity in the aquarium C (Table 1); however, our results could be affected by factors such as the age or health status because of the wild origin of the fish. Environmental and nutritional improvements (e.g., in handling stress, essential fatty acids) also might improve egg production.

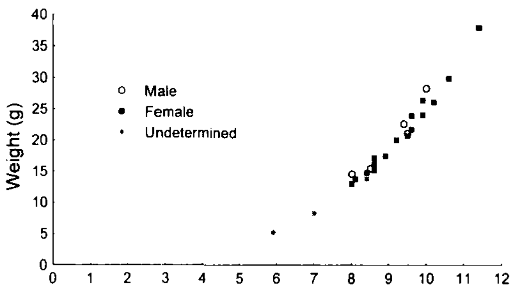

FIGURE 4. *Length, weight and sex of a sample of spotted sand bass at first spawn reared in laboratory.*

It still is not clear whether wild populations of this species normally spawn in harems (i.e., one male and a number of females) or in aggregations (moderate to large numbers of males and females) (Fischer and Petersen 1987; Shapiro 1987), but our observations show that harem spawning is possible.

Early Development

Spotted sand bass follows the typical patterns of embryonic development described for marine teleosts. The 5.3% survival during the first 17 d was typical for serranid larvae (Tucker 1998); however, in a previous study, survival was only 2.5% (Avilés-Quevedo et al. 1995). The causes for 95% mortality are not certain. We found no evidence of cannibalism, as was described by Avilés-Quevedo et al. (1995). Other possible causes such as stress, pathogens, and nutritional deficiencies have not been investigated, but improvements could be made in those areas. For example, *Artemia* and rotifers should have been enriched.

In the present study our objective was not the seed production, however, an acceptable survival was obtained. Recently, the use of better culture systems (recirculating), feeding regime with copepods, and enrichment have contributed to increase the larvae survivals to 11% (Alvarez-González 1999).

The growth of spotted sand bass larvae follows the same pattern of other serranids, with slow growth during the first 15 d (Kayano and Oda 1986; Maneewong et al. 1986; Lim 1993). Since 4 dah we found a decrease in the growth rate (which became negative), corresponding with the exhaustion of the yolk reserves and the beginning of the exogenous feeding. Similar growth patterns has been reported in other marine fish (Quiñonez-Velázquez and Gómez-Muñoz 1986)

In preliminary observations, we found that manipulation of eggs caused collapse and death during the first 12 haf, but not later, after blastopore closure. Red drum *Sciaenops ocellatus* eggs were found to vary by stage in their tolerance to salinity variation (Holt and Banks 1989) and disinfectant treatment (Douillet and Holt 1994).

Growth and Spawning of Reared Fish

Female size at first spawning was similar to that reported by Hastings (1989) for wild fish. However, we found mature males at 80 mm (22 mm smaller than found by this author) (Fig. 4). Although early maturation in fish is good for egg production, it contributes to reduced somatic growth before the fish reach market size (Balarin and Haller 1982). Available data of this species suggest that 400–500 g market size could be reached between 15 and 20 mo of age. Increased growth through sterilization or other genetic manipulation might be necessary for economical commercial production of this species for food.

Acknowledgments

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